

What is claimed is:

1. A process for providing one or more flame retardant properties to one or more substrates having no flame retardant properties, or for enhancing one or more flame retardant properties of one or more substrates having one or more flame retardant properties,  
5 comprising:

(a) applying a flame retardant composition to one or more substrates in an amount that is sufficient to provide one or more flame retardant properties to the substrates, or to enhance one or more flame retardant properties of the substrates, wherein the substrates contain at least about 5 weight percent of  
10 non-thermoplastic material;

(b) removing excess flame retardant composition from the substrates;

(c) optionally, rinsing the substrates with an amount of a rinse liquid that is sufficient to remove any remaining flame retardant composition that is not  
15 necessary or beneficial for providing one or more flame retardant properties to the substrates, or for enhancing one or more flame retardant properties of the substrates;

(d) optionally, removing excess rinse liquid from the substrates;

(e) permitting the substrates to dry for a period of time, and at a temperature, that permits the substrates to have a low moisture content; and  
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(f) applying at least some of the excess flame retardant composition that is removed from the substrates to:

(1) one or more of the same substrates at least one additional time prior to, at the same time as, or after the substrates are permitted to dry; or  
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(2) one or more other substrates of the same or different type;

in an amount that is sufficient to provide one or more flame retardant properties to such substrates, or to enhance one or more flame retardant properties of such substrates;

wherein the flame retardant composition comprises a mixture of:

(1) one or more flame retardant substances in a combined amount that is sufficient to provide one or more flame retardant properties to the  
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substrates, or to enhance one or more flame retardant properties of the substrates;

- 5 (2) an aqueous or non-aqueous liquid in an amount that is sufficient to permit the flame retardant substances to be applied to the substrates in a manner that provides one or more flame retardant properties to the substrates, or enhances the flame retardant properties of the substrates;
- (3) one or more adhesion agents in a combined amount that is sufficient to permit the flame retardant substances to become adhered, or to enhance the adhesion of the flame retardant substances, to one or more surfaces, areas or components of the substrates;
- 10 (4) optionally, one or more stability enhancing agents in a combined amount that is sufficient to provide at least some stability to, or enhance the stability of, the flame retardant composition;
- (5) optionally, one or more viscosity enhancing agents in a combined amount that is sufficient to increase the viscosity of the flame retardant composition; and
- 15 (6) optionally, one or more wetting agents in a combined amount that is sufficient to enhance an ability of the flame retardant composition to penetrate into, or to spread over, one or more surfaces, areas or components of the substrates;
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wherein neither the flame retardant composition nor any rinse liquids contain an amount of a dye or other agent that could contaminate the process.

2. A process of claim 1 wherein the substrates are not separately baked or cured after they are dried.

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3. A process of claim 1 wherein the substrates are not rinsed after excess flame retardant composition is removed from the substrates.

4. A process of claim 1 wherein the process provides substrates that are durable.

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5. A process of claim 1 wherein the flame retardant composition saturates the substrates.

6. A process of claim 5 wherein the flame retardant composition is applied to the substrates using a soaking, immersion, drenching, dipping or impregnation method.

7. A process of claim 1 wherein all of the excess flame retardant composition is recycled and provides one or more flame retardant properties to one or more substrates, or enhances one or more flame retardant properties of one or more substrates.

8. A process of claim 1 wherein the flame retardant composition does not contain any dye, and does not contain any other chemical compound, substance, agent or composition that could contaminate the process.

9. A process of claim 6 wherein excess flame retardant composition is removed from the substrates by separating the substrates from the excess flame retardant composition, by centrifuging the substrates, by squeezing the substrates or using a combination or more than one of the foregoing techniques.

10. A process of claim 1 wherein the aqueous or non-aqueous liquid is an aqueous liquid, the one or more flame retardant substances are phosphoric acid, halogen-free phosphoric acid derivatives, phosphonic acid, halogen-free phosphonic acid derivatives, ammonium polyphosphate, ammonia, ammonia phosphate, ammonium molybdate, ammonium borate, organophosphorus chemicals, melamine, melamine chemicals, intumescent chemicals, alumina trihydrate, urea, guanidine, dicyandiamide, ethyl urea, ethylamine, thiourea, diethylenediamine, ethylenediamine, brominated aromatic organic compounds or brominated cycloaliphatic organic compounds, and the adhesion agent is a cross-linking binder or a polymer or copolymer of an ester of acrylic acid, methacrylic acid, a styrene butadiene copolymer, vinyl chloride, vinylidene chloride, vinyl acetate, acrylonitrile, an acrylamide or a polyurethane ester or ether.

11. A process of claim 1 wherein the substrates are filaments, microfibers, fibers, fibrous compositions, threads, yarns, fabrics, textiles or a blend of any of the foregoing materials.

5           12. A process of claim 11 wherein the substrates are filaments, microfibers, fibers, fibrous compositions, threads, yarns, fabrics or textiles.

13. A process of claim 12 wherein the substrates are filaments, microfibers or fibers.

10           14. A process of claim 6 wherein the substrates are filaments, microfibers or fibers.

15. A process of claim 14 wherein the substrates are fibers.

16. A process of claim 12 wherein the substrates are fabrics.

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17. A process of claim 11 wherein the substrates contain from about 20 to about 100 weight percent of non-thermoplastic material.

20           18. A process of claim 17 wherein the substrates contain about 100 weight percent of non-thermoplastic material.

19. A process of claim 18 wherein the substrates are non-thermoplastic filaments, microfibers or fibers.

25           20. A process of claim 12 wherein the substrates are rayon or cotton fibers, fibrous compositions or fabrics.

21. A process of claim 20 wherein the substrates are rayon or cotton fibers.

22. A process of claim 10 wherein and the pH of the flame retardant composition ranges from about 2 to about 11, and the viscosity of the composition ranges from about 50 to about 1,500 centipoises.

5           23. A process of claim 12 wherein substrates treated with the process are formed into, or used as, a flame barrier substrate, and wherein the flame barrier substrate has the ability to provide at least some protection against combustion to an adjacent material or substrate that does not have any flame retardant properties.

10           24. A process of claim 23 wherein the flame barrier substrate is a fibrous composition, a textile or a fabric.

25. A process of claim 24 wherein the flame barrier substrate is a non-woven fibrous composition.

15           26. A process of claim 25 wherein the flame barrier substrate is employed as a component of a pillow-top or other mattress, a pillow or a cushion.

20           27. A process of claim 10 wherein the crosslinking binder is polyvinyl acetate, a formaldehyde polyacrylate, a polyurethane, a urea-formaldehyde, a polyepoxide resin or a melamine formaldehyde, and the flame retardant substance is a brominated aromatic compound or a brominated cycloaliphatic compound.

25           28. A process of claim 12 wherein the substrates are flax, kenaf, ramie, caroa, bagasse, ficque, banana, cotton, linen, jute, coconut fiber, rayon or hemp fibers, fabrics or fibrous compositions.

29. A process of claim 5 wherein the substrates are fibers, and wherein the treated fibers are subsequently blended with one or more other fibers that do not have any flame retardant properties to produce a homogeneously blended product.

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30. A process of claim 1 wherein the process is environmentally friendly.

31. A process of claim 1 wherein the cost of the flame retardant substances employed is reduced by at least about 75% in comparison with an open loop flame retarding process  
5 that employs the same flame retardant substances and the same amounts thereof.

32. A process of claim 1 wherein the cost of the flame retardant substances employed is reduced by at least about 90% in comparison with an open loop flame retarding process that employs the same flame retardant substances and the same amounts thereof.

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33. A process of claim 1 wherein the treated substrates have a flame retardant coating on one or more surfaces, areas or components thereof that reduces the amount of burning that occurs to the substrates, or the amount or density of smoke produced by the substrates, when the substrates are exposed to a flame in comparison with the same substrates that have not  
15 been treated in this manner.

34. A process of claim 33 wherein the treated substrates have the ability to pass the requirements of the NFPA 701 test.

20 35. A process of claim 34 wherein the treated substrates undergo the NFPA 701 test, and that NFPA 701 test shows that a char length of the treated substrates is less than about 3 inches and that no afterflame is produced.

25 36. A process of claim 10 wherein the one or more flame retardant substances are in a solid particulate form at room temperature.

37. A process of claim 36 wherein the flame retardant substances have an average particle size ranging from about 1 to about 200 microns.

30 38. A process of claim 1 wherein the combined amount of flame retardant substances ranges from about 0.5 to about 75 weight percent of the flame retardant compositions, the

amount of the aqueous or non-aqueous liquid ranges from about 0.5 to about 70 weight percent of the flame retardant compositions, the combined amount of adhesion agent ranges from about 0.5 to about 0.7 weight percent of the flame retardant compositions, and the viscosity of the flame retardant compositions ranges from about 50 to about 1,500 cps.

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39. A process for providing one or more flame retardant properties to one or more substrates having no flame retardant properties, or for enhancing one or more flame retardant properties of one or more substrates having one or more flame retardant properties, comprising:

- 10 (a) applying a flame retardant composition to one or more substrates in an amount that is sufficient to provide one or more flame retardant properties to the substrates, or to enhance one or more flame retardant properties of the substrates, wherein the substrates contain at least about 5 weight percent of non-thermoplastic material;
- 15 (b) removing excess flame retardant composition from the substrates;
- (c) optionally, rinsing the substrates with an amount of a rinse liquid that is sufficient to remove any remaining flame retardant composition that is not necessary or beneficial for providing one or more flame retardant properties to the substrates, or for enhancing one or more flame retardant properties of the
- 20 substrates;
- (d) optionally, removing excess rinse liquid from the substrates;
- (e) permitting the substrates to dry for a period of time, and at a temperature, that permits the substrates to have a low moisture content; and
- (f) applying at least some of the excess flame retardant composition that is
- 25 removed from the substrates to:
- (1) one or more of the same substrates at least one additional time prior to, at the same time as, or after the substrates are permitted to dry; or
- (2) one or more other substrates of the same or different type;
- in an amount that is sufficient to provide one or more flame retardant
- 30 properties to such substrates, or to enhance one or more flame retardant properties of such substrates.

40. A substrate that has been treated according to the process of claim 1.
41. A substrate of claim 40 wherein the substrate is not separately baked or cured after it is dried.
- 5 42. A substrate of claim 41 wherein the substrate is not rinsed after excess flame retardant composition is removed from the substrate.
43. A substrate of claim 40 that is durable.
- 10 44. A substrate of claim 43 wherein the substrate is a filament, microfiber, fiber, fibrous composition, thread, yarn, fabric, textile or a blend of any of the foregoing materials.
45. A substrate of claim 44 wherein the substrate is a filament, microfiber or fiber.
- 15 46. A substrate of claim 44 wherein the substrate is a fibrous composition, fabric or textile.
47. A substrate of claim 44 wherein the substrate contains from about 20 to about 20 100 weight percent of non-thermoplastic material.
48. A substrate of claim 44 wherein the substrate is a rayon or cotton fiber, fibrous composition or fabric.
- 25 49. A substrate of claim 48 wherein the substrate is a rayon or cotton fiber.
50. A substrate of claim 40 wherein the substrate is formed into, or used as, a flame barrier substrate, and wherein the flame barrier substrate has the ability to provide at least some protection against combustion to an adjacent material or substrate that does not have 30 any flame retardant properties.



51. A substrate of claim 50 wherein the flame barrier substrate is a fibrous composition, a textile or a fabric.

52. A substrate of claim 51 wherein the flame barrier substrate is a non-woven fibrous composition.

53. A substrate of claim 52 wherein the flame barrier substrate is employed as a component of a pillow-top or other mattress, a pillow or a cushion.

54. A substrate of claim 45 wherein the substrate is a plurality of fibers, and wherein the fibers are subsequently blended with one or more other fibers that do not have any flame retardant properties to produce a homogeneously blended product.

55. A substrate of claim 40 wherein the substrate has a flame retardant coating on one or more surfaces, areas or components thereof that reduces the amount of burning that occurs to the substrate, or the amount or density of smoke produced by the substrate, when the substrate is exposed to a flame in comparison with the same substrate that has not been treated in this manner.

56. A substrate of claim 40 wherein the substrate has the ability to pass the requirements of the NFPA 701 test.

57. A substrate of claim 56 wherein the substrate undergoes the NFPA 701 test, and that NFPA 701 test shows that a char length of the substrate is less than about 3 inches and that no afterflame is produced.

58. A substrate of claim 45 wherein the substrate is formed into a thread, a yarn, a woven or non-woven fibrous composition, a fabric or a textile.

59. A substrate of claim 58 wherein the substrate is formed into a non-woven fibrous composition.

60. A substrate of claim 40 wherein the substrate is a flax, kenaf, ramie, caroa, bagasse, ficque, banana, cotton, linen, jute, coconut fiber, rayon or hemp fiber, fabric or fibrous composition.

5           61. A substrate of claim 40 wherein the flame retardant substance does not become rubbed off or flaked off of the substrate by mechanical working of the substrate.

62. A system for providing one or more flame retardant properties to one or more substrates having no flame retardant properties, or for enhancing one or more flame retardant  
10 properties of one or more substrates having one or more flame retardant properties, comprising:

- 15           (a) at least one means for applying a flame retardant composition to the substrates in an amount that is sufficient to provide one or more flame retardant properties to the substrates, or to enhance one or more flame retardant properties of the substrates;
- (b) at least one means for removing excess flame retardant composition from the substrates;
- (c) optionally, at least one means for rinsing the substrates with an amount of a rinse liquid that is sufficient to remove any remaining flame retardant composition that  
20 is not necessary or beneficial for providing one or more flame retardant properties to the substrates, or for enhancing one or more flame retardant properties of the substrates;
- (d) optionally, at least one means for removing excess rinse liquid from the substrates;
- 25           (e) at least one means for applying at least some of the excess flame retardant composition that is removed from the substrates to:
  - (1) one or more of the same substrates at least one additional time prior to, at the same time as, or after the substrates are permitted to dry; or
  - (2) one or more other substrates of the same or different type;
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substrates, wherein such means may be the same or different means that is employed for initially applying the flame retardant composition to the substrates; and

- (f) optionally, at least one means for permitting the substrates to dry for a period of time, and at a temperature, that permits the substrates to have a low moisture content;

wherein neither the flame retardant composition nor any rinse liquids contain an amount of a dye or other agent that could contaminate the substrates or the system, and wherein the system is a "closed loop" system that recycles flame retardant composition.

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63. The system of claim 62 wherein the flame retardant composition is a mixture of:

- (a) one or more flame retardant substances in a combined amount that is sufficient to provide one or more flame retardant properties to the substrates, or to enhance one or more flame retardant properties of the substrates;

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- (b) an aqueous or non-aqueous liquid in an amount that is sufficient to permit the flame retardant substances to be applied to the substrates in a manner that provides one or more flame retardant properties to the substrates, or enhances the flame retardant properties of the substrates;

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- (c) one or more adhesion agents in a combined amount that is sufficient to permit the flame retardant substances to become adhered, or to enhance the adhesion of the flame retardant substances, to one or more surfaces, areas or components of the substrates;

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- (d) optionally, one or more stability enhancing agents in a combined amount that is sufficient to provide at least some stability to, or enhance the stability of, the flame retardant composition;

- (e) optionally, one or more viscosity enhancing agents in a combined amount that is sufficient to increase the viscosity of the flame retardant composition; and

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- (f) optionally, one or more wetting agents in a combined amount that is sufficient to enhance an ability of the flame retardant composition to penetrate into, or to spread over, one or more surfaces, areas or components of the substrates; and

wherein the substrates contain at least about 5 weight percent of non-thermoplastic material.

64. The system of claim 62 wherein the system additionally comprises a means for containing the excess flame retardant composition, and wherein such means is separate from the means for applying the flame retardant composition to the substrates.

5           65. The system of claim 64 wherein the means for applying a flame retardant composition to the substrates is a dye machine, the means for removing excess flame retardant composition from the substrates is a centrifuge, a removal of the substrates from the dye machine or a combination of a centrifuge and the removal of the substrates from the dye machine, the means for applying the excess flame retardant composition that is removed  
10       from the substrates to one or more substrates is a separate dye machine and the means for containing the excess flame retardant composition is a storage tank or a dye machine.

66. The system of claim 65 wherein the flame retardant composition is replenished by an addition of flame retardant composition contained in a master mix batch.

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67. The system of claim 66 wherein the system has two separate dye machines, and wherein the system permits the same flame retardant composition to be applied to a first group one or more substrates in a first dye machine, and subsequently permits used flame retardant composition to be applied to a second group of one or more substrates in a second  
20       dye machine.

68. A system of claim 63 wherein substrates treated in the system are durable.

69. A system of claim 62 wherein the system does not rinse any substrates.

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70. A system of claim 62 wherein the system removes excess flame retardant composition from the substrates by removing the substrates from the means for applying the flame retardant composition to the substrates and by separately centrifuging or squeezing the substrates, and wherein the excess flame retardant composition that is removed from the  
30       substrates in these two manners is combined and applied to one or more other substrates.

71. A system of claim 62 wherein the system has two operating phases that operate simultaneously or with alternating cycles.

72. A system of claim 62 wherein when the system is operated, the cost of the flame retardant substances employed in the system is reduced by at least about 75% in comparison with an open loop flame retarding system that employs the same flame retardant substances and the same amounts thereof.

73. A process of claim 72 wherein the cost of the flame retardant substances employed in the system is reduced by at least about 90% in comparison with an open loop flame retarding system that employs the same flame retardant substances and the same amounts thereof.

74. A system of claim 71 wherein the system is the system shown in FIG. 1.

75. A flame retardant composition for application to one or more substrates prior to an exposure of the substrates to fire comprising a mixture of:

- (1) one or more flame retardant substances in a combined amount that is sufficient to provide one or more flame retardant properties to one or more substrates, or to enhance one or more flame retardant properties of one or more substrates, wherein the substrates contain at least about 5 weight percent of non-thermoplastic material;
- (2) an aqueous or non-aqueous liquid in an amount that is sufficient to permit the flame retardant substances to be applied to the substrates in a manner that provides one or more flame retardant properties to the substrates, or enhances the flame retardant properties of the substrates;
- (3) one or more adhesion agents in a combined amount that is sufficient to permit the flame retardant substances to become adhered, or to enhance the adhesion of the flame retardant substances, to one or more surfaces, areas or components of the substrates;

- (4) optionally, one or more stability enhancing agents in a combined amount that is sufficient to provide at least some stability to, or enhance the stability of, the flame retardant composition;
- (5) optionally, one or more viscosity enhancing agents in a combined amount that is sufficient to increase the viscosity of the flame retardant composition; and
- (6) optionally, one or more wetting agents in a combined amount that is sufficient to enhance an ability of the flame retardant composition to penetrate into, or to spread over, one or more surfaces, areas or components of the substrates;
- wherein the flame retardant composition does not contain an amount of a dye or other chemical compound, agent, substance or composition that could prevent the flame retardant composition from producing the same or very similar results between its application to the substrates and, after it has been applied to the substrates, its application at least one time to:
- (b) one or more of the same substrates; or
  - (b) one or more other substrates of the same or different type;
- wherein the flame retardant composition has an ability to provide one or more flame retardant properties to one or more substrates that contain at least about 5 weight percent of non-thermoplastic material and that have no flame retardant properties, or to enhance one or more flame retardant properties of one or more substrates that contain at least about 5 weight percent of non-thermoplastic material and that have one or more flame retardant properties, without containing a metal oxide, when it is first applied to one or more substrates and also after it has been applied to one or more substrates;
- and wherein the flame retardant composition can be applied to the substrates in a "closed loop" process or system for providing one or more flame retardant properties to one or more substrates having no flame retardant properties, or for enhancing one or more flame retardant properties of one or more substrates having one or more flame retardant properties.

76. A composition of claim 75 wherein the composition does not contain a metal oxide.

77. A composition of claim 75 wherein the composition contains a flame retardant substance that contains phosphorous.

78. A method for reducing the burning of, or the amount or density of smoke produced by, one or more substrates containing at least about 5 weight percent of non-thermoplastic material that is exposed to a flame comprising applying a flame retardant composition of claim 75 to the substrates at least one time prior to the substrates being  
5 exposed to the flame.